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IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation-1959 as related primarily to United States programs.

International Geophysical Cooperation-1959

The following material is based primarily on IGY World Data Center A General Report Series, No. 6, United States Program for IGC-59, *which may be obtained from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, N. W. Washington 25, D. C., for $1.00. Only a brief background and a few highlights of the program are given here. The above document should be consulted for a more complete picture, and for specific details on the US IGC-59 program, including names of participating institutions and locations and programs of stations.*

The International Geophysical Year was scheduled to end, in a formal sense, on December 31, 1958. However, world-wide, cooperative research in geophysics during the IGY had proved to be even more valuable than the most optimistic forecasts. Accordingly, at its Fifth Assembly, held in Moscow in August 1958, the international IGY coordinating body, Comité Spécial de l'Année Géophysique Internationale (CSAGI), considered various ways and means whereby the world could continue to reap the benefits of international cooperation in geophysics.

Unanimous agreement was secured to a resolution recommending that observational and data collecting activities in the geophysical and related sciences be continued throughout 1959, on the same general plan as during the IGY but at a level to be determined by each IGY participating committee. CSAGI recommended that the name International Geophysical Cooperation-1959 (IGC-59) be given to this extended effort.

Later in 1958 (October 2–6), the International Council of Scientific Unions (ICSU) held its triennial General Assembly in Washington, D. C. At this meeting, ICSU, the IGY parent organization, adopted a plan for IGC-59. ICSU also established a Special Committee for Inter-Union Cooperation in Geophysics (SCG), consisting of the members of the CSAGI Bureau and of the World Reporters for the various IGY disciplines. Thus, the IGY on December 31, 1958, through IGC-59, entered without interruption into another phase of international, coordinated studies of our planet, in some cases at a higher level of intensity.

Following the pattern of the IGY, the National Academy of Sciences assigned to the US National Committee for IGY (Chairman, Joseph Kaplan; Executive Director, Hugh Odishaw) the responsibility for planning all phases of the US contribution to IGC-59 and for effecting the necessary international cooperation. This approach to IGC-59 was in accordance with the pattern generally followed in other countries which had participated in the IGY.

IGY scientists had recognized very early that some fields would require world-wide study and cooperation far beyond 1959. Accordingly, ICSU established Special Committees for Oceanic Research (SCOR), in August 1957, and for Antarctic Research (SCAR), in February 1958, and a Committee for Space Research (COSPAR) in October 1958.

Following here too the pattern of the IGY, the National Academy of Sciences established in this country the Committee on Oceanography (Chairman, Harrison Brown; Executive Secretary, Richard C. Vetter), the Committee on Polar Research (Chairman, Laurence M. Gould; Executive Secretary, Ross C. Peavey), and the Space Science Board (Chairman, Lloyd V. Berkner; Executive Director, Hugh Odishaw; Secretary, Ross C. Peavey), to cooperate with SCOR, SCAR, and COSPAR, respectively, in coordinating international programs in these fields.

Two other areas invited the special attention of ICSU. During the IGY, the World Warning Agency was a vital factor in the achievement of one of the most important objectives of the IGY: world-wide observation of unusual activity on the sun during a period of sunspot maximum. The notification service of the World Warning Agency proved to be of such importance to solar and upper-atmosphere studies that ICSU established a permanent International World Days Service. Called IWDS, this service is perpetuating a warning alert system similar to that of the IGY, but somewhat simplified.

Finally, ICSU assigned responsibility for a new World Magnetic Survey to the International Association for Geomagnetism and Aeronomy, part of the International Union of Geodesy and Geophysics. This survey of the earth's magnetic field is to be conducted during the next few years, which are expected to be marked by diminishing solar activity, and consequent diminution of magnetic storminess, as contrasted with the sunspot maximum which occurred during the IGY.

Although international coordinating responsibility for programs dealing with the Antarctic, oceanography, space science, world days, and geomagnetism has been vested in groups other than SCG, all of these programs are nevertheless a part of IGC-59.

As noted, responsibility for this country's IGC-59 plans was vested by the Academy in the USNC-IGY. The United States has mounted a program in each of the scientific disciplines studied during the IGY. The US IGC-59 program consists of three parts: (i) contributed efforts from public and private institutions, including regular network operations as well as special projects of various institutions; (ii) incorporation of major programs already funded, including the 1959 Antarctic research program now underway and space science activities as developed by the operating government agencies; and (iii) a small group of projects requiring special funding by the National Science Foundation. Brief notes, including a summary tabulation (Table 1), of the programs planned in each of the IGC-59 disciplines or areas of special study follow.

Earth's Heat and Water Budget

Meteorology: Surface and upper-air meteorological observations are being made at 170 stations operated by the United States, and at 27 stations operated in cooperation with other countries. Special measurements of carbon dioxide and ozone concentrations in the atmosphere are being made at some stations, and some work is being done on oceanographic research vessels on the exchange of CO_2 between sea water and air.

In the Arctic Basin, a new floating station, Station C, was established to take the place of Station A, which had been shut down in November 1958 owing to deterioration of the ice. At Station B (on Fletcher's

TABLE 1
Summary of Programs in IGC-59 Disciplines or Areas of Study

Area of Study or Discipline	Number of Stations			Principal Objectives
	U. S.*	Cooperative**	Total	
Earth's Shape, Crust, and Composition				
Seismology	5	15	20	Further understanding of crustal structure and earthquake phenomena in the U. S., South America, and Antarctica.
Gravity	—	—	—	Fill gaps in world gravity network.
Longitudes and Latitudes	3	—	3	More accurate geodetic measurements and improved standard of time.
Earth's Heat and Water Budget				
Meteorology	170	27	197	Atmospheric circulation and geochemical studies, including carbon-dioxide, solar-radiation, and ozone measurements.
Glaciology	17	4	21	Study structure and behavior of Antarctic and Greenland ice sheets, Alaskan and West Coast glaciers, and the Arctic ice pack.
Oceanography	26	11	37	Measure currents, tides, and chemistry of the oceans.
Nuclear Radiation	148	69	217	Trace radioactivity in air, rain and snow, and ground deposits.
Upper Atmosphere, Sun, and Space				
Airglow	3	2	5	Record airglow emissions.
Aurora	26	18	44	Obtain information about auroras in relation to other upper-atmosphere phenomena.
Cosmic Rays	14	6	20	Register cosmic-ray intensity and geographic variations, using ground and airborne devices, in relation to solar events and magnetic fields.
Geomagnetism	21	7	28	Study equatorial electrojet and subaudio signals, and their relation to magnetic storms, and continue some network studies of magnetic variations.
Ionospheric Physics	30	41	71	Extend knowledge of the ionosphere and its effects on communications.

TABLE 1—*Continued*
Summary of Programs in IGC-59 Disciplines or Areas of Study

Area of Study or Discipline	Number of Stations			Principal Objectives
	U. S.*	Cooperative**	Total	
Solar Activity	13	—	13	Continue visual and radio solar patrols, and special solar studies; observe solar eclipse of October 2.
Space Science	—	—	—	Extend knowledge of the upper atmosphere, the sun, and space by means of rockets, satellites, space probes and ground-based experiments.
World Days	—	—	—	Continue warning alert and special observation days systems of IGY.
Antarctic				
All Disciplines	2	4	6	Extend knowledge of oceans, weather and climate, and upper-atmosphere phenomena of Antarctica; make geological, geodetic, glaciological, biological, and medical observations.
Totals —	478	204	682	

*These are stations equipped and operated by U. S. personnel and located in the U. S., its territories, or possessions.

**These are stations operated on a cooperative basis with other countries and located in these countries or their possessions, or in the Antarctic. At these stations, the U. S. has supplied equipment, personnel to help install equipment and make observations, or both.

Ice Island, or T-3) special surface observations, including carbon-dioxide and solar-radiation measurements, are continuing, while at Station C a full meteorological program, including upper-air soundings, is under way.

Glaciology: Continuing Arctic glaciological work includes study of the behavior of glaciers in Southern Alaska; in cooperation with Denmark on the Greenland ice cap, movement and ice-mechanics studies, as well as tests of very deep-drilling techniques for subsequent use in the Antarctic; and, on the two floating stations, study of stratigraphy and petrofabrics of the ice pack and the heat budget of the Arctic Ocean ice-sea-atmosphere system.

Among other projects in the United States, glaciologists re-occupied for the summer a station on Blue Glacier in the Olympic National Park to continue study of its mass and energy regimen, the mode and mechanism of flow in the ice tongue of the glacier, internal structure, and oxygen-isotope ratios.

Oceanography: Twenty-six US and 11 cooperative stations are being operated in the oceanography program. Ship operations are being conducted in both the Pacific and Atlantic, continuing profile studies in the Atlantic and study of current systems in the Pacific.

Marine geophysical studies are continuing at Drifting Station B, in the Arctic Basin, and oceanographic studies similar to those carried out at Station A during the IGY are continuing on the new drifting station, Station C.

With the cooperation of such groups as this country's Committee on Oceanography of the National Academy of Sciences, SCOR has developed definite plans for further studies of the oceans, culminating in an international cooperative investigation of the largest unknown area on earth, the 28,350,000 square-mile Indian Ocean, over a complete monsoon period in 1962–63.

Nuclear Radiation: At 148 stations operated by the United States, and at 69 stations operated in cooperation with other countries, measurements of the radioactivity of the air, of solid particles deposited on the ground, and of precipitation at the earth's surface, are being continued. This program was developed during IGY in accordance with a recommendation made by CSAGI at its Fourth Meeting, in Barcelona, in September 1956.

Upper Atmosphere, Sun, and Space

World Days: As part of the International World Days Service (IWDS), the IGY World Warning Agency (AGIWARN) operated at Fort Belvoir, Virginia, by the North Atlantic Radio Warning Service of the National Bureau of Standards, will now be known as the World Warning Agency (WWA). WWA will continue with the responsibility of issuing IGC alerts and Special World Intervals. As during the IGY, a program of Regular World Days is also under way.

Airglow: At three US stations, and at two cooperatively operated with other countries, automatic scanning photometers are in use. Launching of rockets carrying airglow observing equipment is also planned as a contribution to IGC-59.

Aurora: At 20 stations, all-sky cameras are continuing to photograph the aurora every minute. All-sky cameras are also in operation at nine stations cooperatively maintained by the United States and other countries. A new type of all-sky camera is being used in Alaska to determine auroral heights by triangulation as a part of broad spectroscopic studies of auroral phenomena and their dependence on height. It is hoped to inaugurate in Alaska interdisciplinary observations of phenomena related to aurora, possibly in coordination with similar programs at geomagnetically opposite locations in New Zealand.

Visual, radar, and spectroscopic observations of the aurora are continuing at many locations. Special studies are planned to investigate zodiacal light for information on interplanetary media. It is planned to launch high altitude rockets at Fort Churchill, Canada, in the fall of 1959, to carry ultraviolet scanning spectrometers into the aurora. A battery of filters will also be carried to get the vertical emission profile. Altogether, there are 26 stations being operated by the United States in the aurora program for IGC-59, and 18 stations are being operated cooperatively with other nations.

Cosmic Rays: In the field of cosmic rays, 14 US and six cooperative stations are in operation. Four institutions are conducting balloon observations in the United States and Canada. At least one rocket and probably several satellite vehicles will carry cosmic-ray equipment. An air-borne neutron monitor will be used to survey the geomagnetic equator and to study latitude variations of cosmic-ray intensity. Neutron monitors, ionization chambers, and meson telescopes are being operated at many stations for continuous registration of cosmic-ray intensity.

Geomagnetism: Twenty-one stations are being operated by the United States alone, and seven are being operated in cooperation with other countries, including four in Peru with the cooperation of the Instituto Geofisico de Huancayo. The regular United States magnetic observatories are continuing to supply data to the World Data Centers during IGC-59. The special networks

established during the IGY to study the equatorial electrojet and sub-audio signals and their relationships to magnetic storms are also continuing.

Ionospheric Physics: Thirty US and 41 cooperative stations are being operated in the US IGC-59 ionospheric physics program. Measurements employing vertical soundings with modern ionosondes are taken every 15 minutes, with increased schedules on Regular World Days and during Special World Intervals. In addition to continued studies of backscatter, trans-equatorial propagation, radio noise, whistlers, and ionospheric absorption of extra-terrestrial radio signals, several groups will observe and analyze ionospheric effects upon satellite radio signals.

Solar Activity: Thirteen stations are being operated by the United States in this program, which includes continuations of optical patrols of the sun's corona, plages, flares, sunspots, and active-region magnetic fields, supplemented by solar-radio-noise patrols and radio spectroscopic observation. Expeditions to Fuerteventura, in the Canary Islands, and to French West Africa, observed the total solar eclipse of October 2, 1959. The solar-activity program also includes special rocket experiments.

Space Science: The United States space science contribution to IGC-59 is being made by several agencies through the Space Science Board. Results of appropriate launchings are expected to be made available to the World Data Centers and to COSPAR. The US space science program has been placed on as broad a basis as possible. By the end of 1959, about 75 sounding rockets and several satellites and space probes will have been launched as a contribution to IGC-59.

The satellite and space-probe contribution is largely being made by the National Aeronautics and Space Administration.

Contributions to the rocket sounding program are being made by many public and private institutions. Emphasis is being placed upon experiments relating to atmospheric structure, electric and magnetic fields, astronomy, energetic particles, and the ionosphere. In addition, under the sponsorship of COSPAR, a World Rocket Week has been set up for the week of November 16, 1959, and the United States will participate with several rocket launchings.

Earth's Shape, Crust, and Composition

Seismology: Most of the IGY network seismological stations are continuing in operation during IGC-59. Two Benioff extensometers, or strain seismometers, are being operated in Chile and in Peru as cooperative programs; they are used to determine the strain pattern of the region. The program for studies of the structure of the earth's crust under the Andes is being extended to include a network for observations of local and regional earthquakes.

Gravity: Gravity determinations by United States groups are assisting in completion of a world network; gravity measurements at sea employing the Graf sea gravimeter and pendulum equipment are also being continued.

Longitudes and Latitudes: During IGC-59 the US Naval Observatory will continue to be the central agency for the moon position program. Photographic observations of the moon, using the dual-rate camera, and determination of astronomical longitudes and latitudes by means of the Danjon impersonal astrolabe are continuing at three stations—in Washington, D. C.; near Honolulu; and in San Diego.

Antarctica

The United States program for scientific research in the Antarctic during 1959 was developed by the Academy's Committee on Polar Research in collaboration with various federal and private agencies in the United States. The program is being carried out under the direction and coordination of

the National Science Foundation. Logistic support is furnished principally by the United States Navy. Coordination with international plans for continued cooperation in Antarctic research has been effected through the Academy's participation in the deliberations of SCAR.

The US IGC-59 program in Antarctica includes projects in aurora, cosmic rays, geomagnetism, ionospheric physics, glaciology, meteorology, and oceanography. In addition, special programs are being conducted in geology, geodesy, cartography, and biological and medical sciences.

Two United States Antarctic stations, the Byrd and Pole Stations, are staffed fully by American personnel. Hallett Station and the Scott/McMurdo complex have joint New Zealand-United States staffs. Wilkes Station and Ellsworth Station have Australian-United States personnel and Argentine-United States personnel, respectively.

World Data Center A

World Data Center A continues as one of the three data centers set up during the IGY. World Data Center B is in the USSR, and World Data Center C is in Western Europe, Australia, and Japan.

World Data Center A was established in 11 institutions in the United States in accordance with the Academy's belief that the interests of science would best be served by housing the data in institutions with histories of scientific interest and competence in particular geophysical disciplines. Data collected during the US IGC-59 program will be collected in World Data Center A and will be exchanged with the other World Data Centers.

Rocket Measurements Through an Aurora

The following material was prepared by J. E. Jackson and J. C. Seddon of the National Aeronautics and Space Administration. The experiment described was an IGY project of the US Naval Research Laboratory, with which the authors were associated at the time.

An important phase of the IGY rocket research program at Fort Churchill, Canada, involved ionosphere studies. *Bulletin No. 20* reported on the aims, techniques, and results of three successful Aerobee-Hi rocket flights carrying experiments designed to investigate electron densities in this region of the earth's upper atmosphere.

New data were gathered on November 24, 1958, when another Aerobee-Hi instrumented to measure ionospheric electron densities was launched directly into an overhead auroral display. The Fort Churchill rocket facility is especially well located for this type of experiment (see Fig. 1).

It was possible to place the rocket into the aurora largely through the valuable advice and assistance of L. R. Davis and H. M. Caulk. The rocket instrumentation was developed by G. H. Spaid and L. A. Lohr; W. L. Joosten, Jr., and E. D. Lee operated the ground instrumentation for the CW propagation experiment (see below). Davis, Caulk, Spaid, and Lohr, now with NASA, were associated with NRL at the time; Joosten and Lee are with the New Mexico College of Agricultural and Mechanic Arts.

The 200-man team operating the Fort Churchill rocket facility consisted of military and civilian personnel of Canada and the United States. Their excellent cooperation under the able management of Lt. Col. L. G. Smith of the US Army Ordnance Corps, along with the well planned facilities of Fort Churchill, resulted in the high efficiency and flexibility of operation neces-

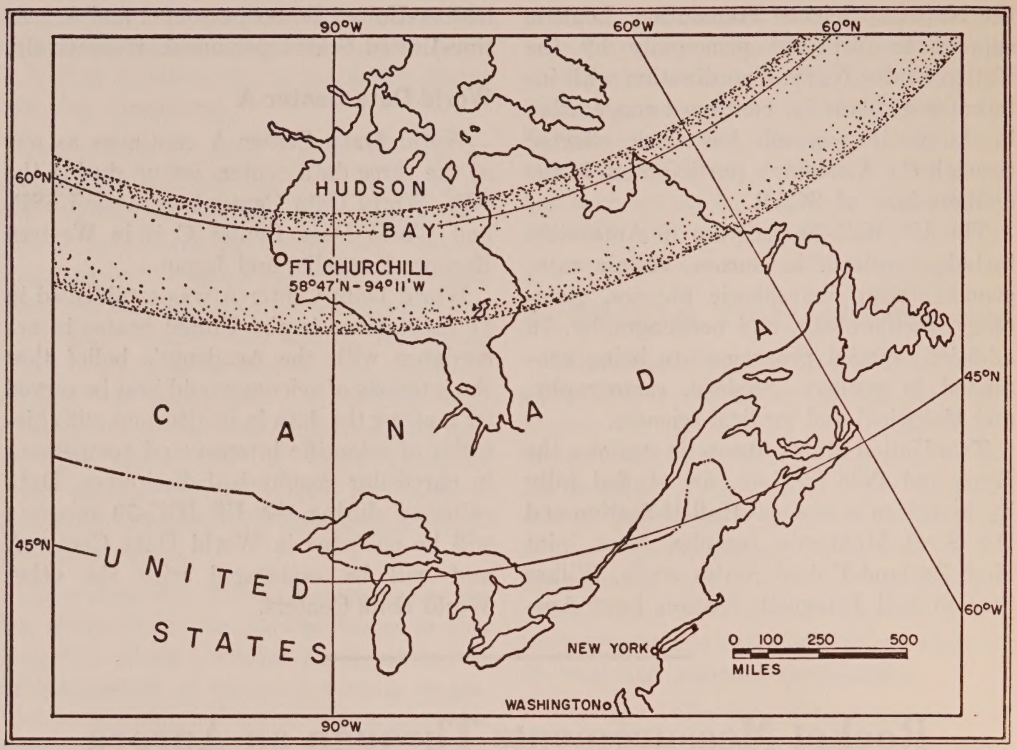

FIG. 1. *Location of Fort Churchill, Canada, Rocket Research Facility, in the Heart of the Zone of Maximum Auroral Frequency.*

sary for the success of this difficult experiment.

This report describes the experiment and summarizes the results.

Launching

To achieve the difficult objective of penetrating an aurora with a scientifically instrumented rocket, three conditions had to be met: (1) there had to be auroral activity with *overhead* displays; (2) clear skies were needed so that the aurora could be seen; and (3) suitable winds were necessary for the rocket launching. Since such an experiment obviously could not be scheduled for any specific night, the entire rocket range was held in continuous standby status. The rocket was kept in the tower, completely fueled and with its instrumentation ready for flight. The project scientists then waited for nature to cooperate.

Whenever circumstances appeared favorable, an alert was issued; two hours later, the entire rocket range could be ready for a launching. The launching "count-down" was held at —3 minutes if auroras were nearby and it appeared that a display might move overhead. If this did not happen within 30 minutes, the rocket pressure system was relieved and time reverted to —20 minutes. This procedure was repeated many times and on several nights, until, on November 24, 1958, the proper conditions were met and the rocket was successfully launched into an aurora.

As observed from the ground, the aurora showed rayed east-west bands of medium intensity just before rocket take-off. These deteriorated to a single weak band at the time of rocket penetration. The visual aurora disappeared completely during the rocket flight.

Experimental Techniques

A number of well-known experimental techniques were employed: (1) a two-frequency, CW (carrier-wave) radio-propagation experiment, using frequencies of 7.75 and 46.5 megacycles; (2) measurement of Faraday rotation (rotation of the plane of polarization of radio waves) at 46.5 mc; (3) analysis of irregularities in the DOVAP (Doppler-velocity-position) data; and (4) interferometer measurements at 46.5 mc (similar to Vanguard Minitrack).

The first three techniques measure, in effect, the rate of change of the total electron-density content between the rocket and the ground. If the rocket travels vertically above the ground station, and if the electron-density distribution remains unchanged with height during the flight, the density at any rocket altitude can be computed.

The fourth technique yields, under free-space (vacuum) conditions, the direction cosines of the rocket position vector. Comparison of these interferometer results with actual trajectory data reveals the errors introduced into the position-vector data by changes in the ionosphere. These errors, when separated out and analyzed, provide information about the ionospheric changes causing them.

Results

Electron densities greater than $10^6/cm^3$ were measured in the E region of the ionosphere (approximately 90–130 km) during the aurora. Both the DOVAP and Faraday data agree quite well in this respect. These large densities were also evidenced by the severe attenuation and weakening of the 7.75-mc signals. Subsequent reappearance of strong 7.75-mc signals after the aurora had dissipated indicated that the average densities along their propagation paths had dropped to values smaller than 5×10^5 electrons/cm^3.

Since all the measuring techniques used are sensitive to the total propagation path, changes in the lower ionosphere cause the higher-altitude data to be very misleading. In fact, the low-altitude variations were so great and so rapid that above a height of 140 kilometers the total electron content appeared to be decreasing during the rocket ascent, yielding what seemed to be "negative electron densities."

The rapid changes in the E region were apparent in the P′-f (vertical incidence) records taken at the time the rocket entered the E region and again, two minutes later, when the rocket entered the F2 region. The F2-region trace was almost completely obscured in the first P′-f ionogram, but clearly visible in the second. The P′-f records support the conclusion reached from the rocket data that the initially high E-region densities must have decreased substantially, and rapidly, during the rocket experiment.

The interferometer results provide similar evidence. At low altitude the interferometer data agree with the actual trajectory. In the E region, however, violent irregularities were detected in spite of the fact that the frequency used, 46.5 mc, is normally not affected by this region of the ionosphere.

Conclusions

The observations provided by the various methods used are compatible with theories that the aurora produces dense cores of ionization along the lines of force of the earth's magnetic field. Dipole antennas on the ground, set to receive signals at 46.5 and 76 megacycles (the DOVAP frequency), did not show "nulls" as the rocket rotated about its axis while passing through the aurora. Instead, they both showed erratic variations in signal intensity. Thus, when this is considered along with the large apparent irregularities in electron density noted on the 46.5-mc interferometer record and the observed average densities in excess of 10^6 el/cm^3, it seems likely that the maximum densities in these auroral ionization cores

might reach a value as high as 10^7 el/cm^3. However, these filaments of intense ionization are spaced sufficiently far apart to allow relatively free transmission of low-frequency signals.

Electron-density profiles obtained in the complete absence of local auroral activity (see *Bulletin No. 20*) show densities much lower than those measured in the aurora; normal winter-night densities, for example, were less than 10^4 el/cm^3 in the E region. Hence, it may be concluded that the large densities noted in this region during the aurora were due entirely to auroral effects.

IGY Satellite 1959 Eta

The sixth US-IGY earth satellite, 1959 Eta (Vanguard III) was launched from Cape Canaveral, Florida, at 1:20 am EDT, September 18, 1959, and went into orbit about 10 minutes later. The satellite was a project of the Goddard Space Flight Center of the National Aeronautics and Space Administration (NASA).

This was the last of the Vanguard satellites scheduled as part of the IGY program, and represents a contribution to the IGY and its extension, IGC-59. It may also be considered a contribution to the continuing international space-science effort brought into being by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU), the parent body of IGY and IGC-59.

Aboard 1959 Eta are experiments to measure the earth's magnetic field, X-radiation from the sun, and several aspects of the space environment through which the satellite travels. For the magnetic field measurements, a new-type magnetometer capable of much greater accuracy than those in previous satellite experiments is being used.

Launching

The launching vehicle used to put 1959 Eta into orbit was, with two exceptions, essentially the same as those used to launch 1958 Beta (Vanguard I) and 1959 Alpha (Vanguard II). (See *Bulletins 11 and 22* for further information about these earlier Vanguard satellites.)

The first two stages of the 72-foot, 22,600-pound Vanguard rocket remained the same, but the third stage was a new, more efficient, solid-propellant rocket made by Hercules Powder Company's Allegany Ballistics Laboratory. Its 10-second-longer burning time made it possible to orbit a payload weighing more than twice as much as those of previous Vanguard instrument packages. The Fiberglas, cylindrical third-stage rocket generates a thrust of about 3000 pounds.

The third-stage casing, weighing about 50 pounds, did not separate from the payload after engine burn-out, as in previous Vanguard launchings. It will remain attached to the instrument package throughout the lifetime of the satellite, providing a larger target for optical trackers. Other reasons for leaving the third stage attached were to minimize precession, or wobbling, of the satellite during its earlier orbits, and to prevent collision between the third stage and the satellite in the event that the rocket engine had continued to burn, or had "coughed," after release of the satellite.

Satellite Characteristics

The satellite is a 50-pound, 20-inch-diameter sphere with a 26-inch, conical tube (housing the magnetometer sensor) protruding from its top. The tube ranges from 2½ to 6 inches in diameter. The main part

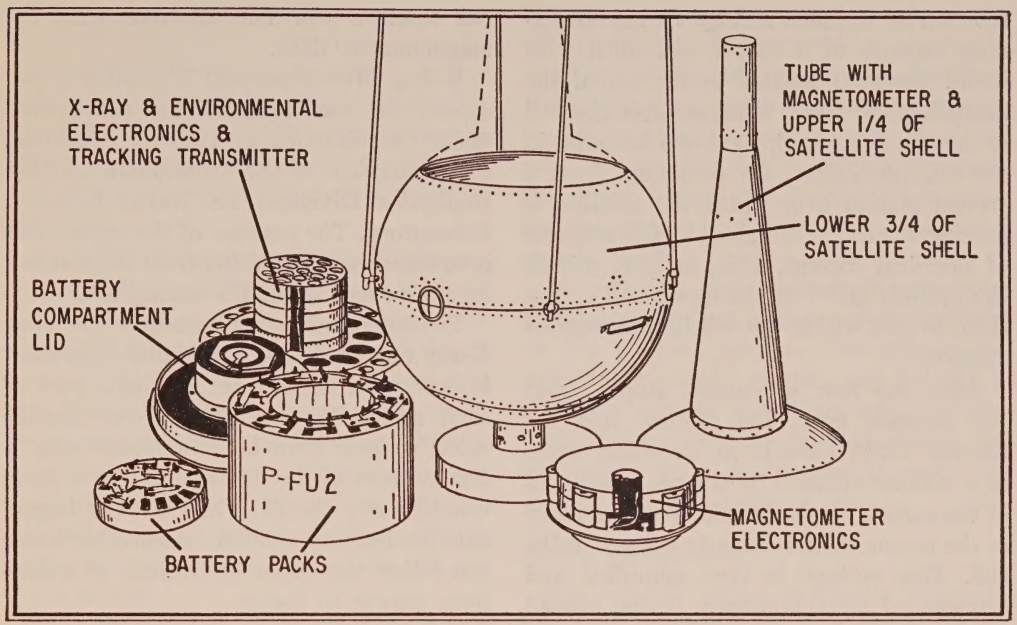

Fig. 2. *Shell and Instrumentation of 1959 Eta. The ionization chamber is located behind the circular window at left-center of the satellite shell; the linear strip at right-center of the shell is an erosion gauge. Adapted from NASA photograph.*

of the satellite shell and internal structure is magnesium. The magnetometer tube is fabricated of glass fibers and phenolic resins, and the forward part of the satellite sphere, to which the tube is attached, is also Fiberglas.

Four antennas, situated 90° apart, extend outward in the equatorial plane of the satellite. These were folded upward prior to release of the satellite, but sprang outward when the nose cone was released.

Experiments and Instrumentation

The three experiments in 1959 Eta, one involving several types of measurements, constitute the greatest variety of studies included in any single US-IGY satellite thus far. (See Figure 2). NASA's project officer for the 1959 Eta experimental payload is R. W. Stroup, Senior Project Coordinator, Satellite Applications Systems Division.

Magnetic Field Measurements: The magnetometer experiment is directed by J. P. Heppner of NASA's Space Sciences Division. With its day-to-day readings from varying altitudes and geographic locations, this experiment will help to chart the earth's magnetic field in space. These measurements are of special importance to future manned space explorations since the charts made from this and similar magnetic-field studies in the future will indicate the best routes to avoid regions of intense radiation trapped in the magnetic field.

The experiment is also providing data that will aid in a better understanding of magnetic storms—solar-related disturbances of the magnetic field which render virtually useless tools relying on the magnetic field, such as the magnetic compass and surveying and navigational instrumentation. The magnetic data will also supply further information about electric currents in the ionosphere, hitherto investigated directly only at a few isolated locations and for short time intervals with rockets.

The magnetometer, designed and con-

structed by Heppner and by Varian Associates, consists of a copper coil filled with liquid (hexane) located in the tip of the magnetometer tube. Wires connect the coil to the electronic equipment and batteries in the satellite sphere. On command from a ground station over which the satellite is passing, the coil is energized by 6½ amperes of electrical current. This, in turn, orients the protons (H^+) in the liquid and causes them to spin within the coil in a prescribed manner.

After the flow of current stops, about two seconds later, the protons spin for another 2-2½ seconds in wobbling orbits in a manner dictated by the characteristics of the earth's magnetic field. The frequency of the proton motion imparts voltage to the coil. This voltage is then amplified and transmitted instantaneously to the ground receiver, where it is taped. Simultaneously, a reading is made at the ground magnetometer, with which each of the interrogating stations is equipped.

Analysis and comparison of the satellite and ground readings will supply much information about the shape, intensity, and variations of the earth's magnetic field. Besides providing additional calibrations for determination of the main geomagnetic field, the simultaneous readings at ground stations will help locate and define ionospheric currents, since measurements both above and below the ionosphere are needed to delineate such currents.

The satellite is interrogated about 50 times a day for magnetic data, or about twice on each pass over a tracking station. The length of the command signal and of the telemetered data varies according to altitude, battery voltage, and satellite temperature, which may range from —10°C to 50°C (14° to 122°F). The satellite is in range of a tracking station for about eight minutes on each pass. It is expected that the magnetometer tube will precede the sphere in flight during the initial orbits, but, in any event, later tumbling or wobbling of the satellite will not interfere with the magnetometer data.

X-Ray Measurements: The solar X-ray experiment was designed and constructed under the direction of Herbert Friedman, Superintendent of the Atmosphere and Astrophysics Division, US Naval Research Laboratory. The purpose of the experiment is to measure X-radiation from the sun and its effects on the earth's atmosphere.

The instrumentation measures the solar X-ray flux and records the solar-flare peak intensity throughout the daylight part of each orbit. Previous solar X-ray studies using rockets were able to record only a few minutes of the development of a flare, usually after the flare had already begun. Satellite instrumentation, on the other hand, can follow the entire life history of a flare from growth to decay.

Two identical ionization chambers sensitive to wavelengths of 1–10 Angstroms (X-rays in this range are produced in solar flares) are the main components of the X-ray instrumentation. The ionization chambers, which record the ionic charge produced by the X-rays, are oriented about 120° apart on the satellite's equatorial plane. The maximum signal occurs when an ion-chamber tube "looks" in the direction of the sun.

The X-ray instrumentation also includes an electrometer circuit for amplifying currents generated in the ionization chambers and a peak-reading memory device. The memory device retains the maximum X-ray signal received during an orbit. This memory core is the controlling element in an audio oscillator that modulates (alters the frequency or amplitude of) the Minitrack signal with the ion-chamber signals. Actually, two cores are used in an orbital switching arrangement: while the core containing the maximum signal from the preceding orbit is modulating the transmitter, the second core is storing data from the current orbit. The roles are reversed as the satellite passes from the night to the day

portion of the orbit, and when the satellite is interrogated, by a switching arrangement using a light-sensitive solar cell. Analysis of the modulated signal provides information on the intensity variations and energies of X-rays entering the chamber. A third core transmits instantaneous values of radiation.

Environmental Measurements: The space-environment experiment is directed by Herman E. La Gow, Head of the Planetary Atmospheres Branch at NASA's Goddard Space Flight Center. This experiment will help provide a more accurate knowledge of environmental conditions in space, which is essential to the design of future satellites and manned space vehicles. Four different kinds of measurements are made by instrumentation both within and on the surface of the sphere.

Two thermistors (tiny thermometers) mounted on the inside wall of the satellite provide a time history of the average shell temperature and of temperature fluctuations throughout the orbit. A third thermistor measures the internal temperature of the solar X-ray instrument compartment. Two hermetically sealed pressure zones girdling the interior walls of the satellite are designed to record the impact of micrometeorites large enough to pierce the satellite shell. The zones, which cover about 20% of the area of the shell, have been drained of enough air to make them partial vacuums, each at a different pressure. A differential pressure gauge is located between the zones and connected to both of them. If either zone is punctured, data indicating which zone it was is telemetered as a change in length of one of the telemeter channels.

Erosion of the satellite shell through bombardment by dust, micrometeorites, ions, molecules, and atoms is recorded by three chromium-strip erosion gauges on the satellite surface and by a photosensitive detector. Electrical resistances of the gauges change as their surfaces are changed by erosion. The photosensitive detector, a cadmium-sulphide cell protected by an opaque covering of Mylar plastic and deposited aluminum, also shows a resistance change as the covering is eroded or penetrated. As with the pressure zones, erosion measurements are telemetered as channel lengths, but in this case permitting estimates of the erosion rates.

In addition, four barium-titanate-type microphones record micrometeorite impacts on the sphere's surface. The microphone output is amplified, shaped, and fed into a magnetic counter unit. This unit provides continuously, in three-decimal digits, the cumulative count of impacts. It counts up to 1000 and then resets to zero.

Radio Equipment

The satellite carries two radio transmitters. One transmits continuously a 108.00-megacycle tracking signal modulated by the X-ray and environmental data, except during the brief periods of operation of the other transmitter when this modulation ceases temporarily. The second transmitter, when interrogated by a ground station, sends stored magnetometer data at 108.03 megacycles. The power level of the 108.00-megacycle transmitter is about 30 milliwatts and that of the 108.03-megacycle transmitter is about 80 milliwatts. It is expected that the batteries powering the satellite instrumentation will have a lifetime of about three months.

Tracking

Satellite 1959 Eta is being tracked by 9 NASA Minitrack stations. These are located at Blossom Point, Maryland; Santiago, Chile; Antofagasta, Chile; Lima, Peru; Quito, Ecuador; Antiqua Island, B.W.I.; San Diego, California; Esselen Park, South Africa; and Woomera, Australia. All 9 stations received good signals from the satellite during the first day after launch.

Through the Amateur Radio Relay League, amateur radio operators were asked

to record as many 108-megacycle transmissions as possible during the first four weeks of the satellite's lifetime. It was hoped that this would broaden the possibility of catching a solar flare at the right moment or of catching parts of a flare that might be missed by the NASA ground stations.

The satellite is being tracked optically by the widespread network of Moonwatch teams and with Baker-Nunn tracking cameras at stations set up as part of the IGY program. (See *Bulletin No. 12* for a listing of these stations.) The optical tracking, under a grant from NASA, is supervised by the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts.

The first Moonwatch sighting of 1959 Eta was made at 0250 UT, September 19, at China Lake, California, by the team led by Carroll L. Evans, Jr. During the first three days after launch, a total of 11 Moonwatch teams observed the satellite. The Tokyo Baker-Nunn station photographed 1959 Eta at 0931 UT, September 18. This first Baker-Nunn photograph of the satellite was made only 4 hours and 11 minutes after launch time. Three more Baker-Nunn stations, one in Spain and two in the U. S., photographed the satellite a total of 10 times in its first two days in orbit.

Orbital Data

The following approximate orbital information for 1959 Eta was announced on September 18, after the satellite had circled the earth several times: perigee, 320 statute miles; apogee, 2329 statute miles; period, 130 minutes; inclination of orbit to equator, 33°; velocity at perigee, 18,567 statute miles per hour; and velocity at apogee, 12,631 statute miles per hour.

WWA Decisions and Geomagnetic Disturbances
February 1—June 30, 1959

This report on results of the World Days Program being carried out under the International Geophysical Cooperation—1959 covers the period February 1-June 30, 1959. (See *Bulletin No. 23* for a report on the previous four months, the concluding period of the IGY program, and on the organization of the IGC-59 World Days Program.)

In February and March, geomagnetic disturbances generally were minor in intensity, and were associated with mild terrestrial effects. A significant exception was the geomagnetic storm which began on March 26. Although not as severe as some storms which occurred during the IGY period, it was accompanied by a longer period of disturbed radio quality—3½ days—than has been associated with any single geomagnetic disturbance in several years.

Ten geomagnetic disturbances occurred during the April-June quarter. Special World Intervals were declared by the World Warning Agency (WWA) to accompany the two most severe storms, those of April 9 and May 11, and the disturbance of June 11, which, although minor, was unusual because it apparently was associated with solar activity on a part of the sun that was not visible at the time the activity occurred.

Seventeen disturbed 6-hour radio-quality figures were recorded during the ten magnetic disturbances of the quarter. Two whole-day radio disturbances were noted, accompanying the magnetic storms of May 11 and May 15.

A list of geomagnetic disturbances, Special World Intervals (SWI), world-wide geophysical Alerts, and major solar flares (those which at least one observatory evaluates as 3 or 3+ in importance) for the period February 1-June 30, 1959, follows:

Feb	2	1017	Class 3 flare
		1816	Class 3 flare; sudden short-wave fadeout and gradual recovery
	9	0810	Class 3 flare
	10	0817	Class 3 flare
	11	0756	Minor magnetic storm begins
		xxxx	World-wide geophysical Alert issued
	12	xxxx	Alert ends
		2300	Class 3 flare; slow short-wave fadeout and gradual recovery
	13	01xx	Minor magnetic storm ends
	14	1143	Minor magnetic storm begins
	17	12xx	Minor magnetic storm ends
	19	2035	Class 3 flare; slow short-wave fadeout
	25	0215	Magnetic storm begins
		xxxx	Alert issued, advising of storm and expected auroras
	26	xxxx	Alert ends
Mar	4	00xx	Magnetic storm ends
	19	1038	Class 3 flare; sudden short-wave fadeout and gradual recovery
	21	0917	Class 3 flare; sudden short-wave fadeout
	24	0709	Class 3 flare; slow short-wave fadeout
		0958	Class 3 flare; sudden short-wave fadeout
	26	0842	Severe magnetic storm begins; prolonged period of disturbed radio quality
		xxxx	Alert issued, advising of storm and expected auroras
	28	2114	Class 3 flare; sudden short-wave fadeout
		xxxx	Alert ends
	30	14xx	Severe magnetic storm ends
Apr	4	0646	Class 3 flare
	5	2316	Class 3 flare; sudden short-wave fadeout and gradual recovery
	8	0916	Class 3 flare; sudden short-wave fadeout
	9	1827	Magnetic storm begins
	10	xxxx	Alert issued
		xxxx	SWI starts
		23xx	Magnetic storm ends
	11	xxxx	Alert ends
		xxxx	SWI finishes
	13	0831	Class 3 flare; sudden short-wave fadeout
	23	1036	Magnetic storm begins
	24	17xx	Magnetic storm ends
May	4	2022	Minor magnetic storm begins
	5	16xx	Minor magnetic storm ends
		0605	Class 3 flare; sudden short-wave fadeout
	7	2130	Minor magnetic storm begins
	8	12xx	Minor magnetic storm ends
	10	2055	Class 3 flare; slow short-wave fadeout and gradual recovery
		2310	Class 3 flare
	11	2010	Class 3 flare; sudden short-wave fadeout
		2330	Severe magnetic storm begins
	12	xxxx	Alert issued
		xxxx	SWI starts
	13	01xx	Severe magnetic storm ends
		xxxx	Alert ends
		xxxx	SWI finishes
	15	11xx	Magnetic storm begins
	16	xxxx	Alert issued
		12xx	Magnetic storm ends
	17	xxxx	Alert ends
		0523	Class 3 flare; sudden short-wave fadeout and gradual recovery
	24	0540	Magnetic storm begins
		xxxx	Alert issued
	25	12xx	Magnetic storm ends
		xxxx	Alert ends
June	2	1810	Class 3 flare; sudden short-wave fadeout and gradual recovery
	6	0945	Class 3 flare
	11	0613	Class 3 flare
		0910	Minor magnetic storm begins (associated with unusual solar activity)
		1902	Class 3 flare
		xxxx	Alert issued
		xxxx	SWI starts
		22xx	Minor magnetic storm ends
	12	0821	Class 3 flare
		xxxx	Alert ends
		xxxx	SWI finishes
	16	0618	Class 3 flare; sudden short-wave fadeout and gradual recovery
	17	1450	Class 3 flare
	18	1130	Class 3 flare

IGY Bibliographic Notes

This is the fifteenth of a series of bibliographic notes on IGY and IGC-1959 programs and findings. In this issue, the Notes are devoted entirely to the status of the IGY Annals.

Eleven volumes of the *Annals of the International Geophysical Year* have been published or are in preparation, and future volumes are planned. The *Annals* will constitute a central record of IGY activity, formal proceedings, technical manuals and results. They are published by the Pergamon Press, Ltd., 122 East 55th Street, New York 22, N. Y., and 4 & 5 Fitzroy Square, London, W. 1.

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Part I, "The First International Polar Year," pp. 1–203.
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Part III, "The Third Meeting of the CSAGI," pp. 203–296.
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Part II, "Aurora and Airglow," pp. 23–138.
Part III, "Longitudes and Latitudes," pp. 143–201.
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Part VII, "Cosmic Radiation," pp. 349–393.

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Part IV, "Solar Activity," pp. 249–301.
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Part VI, "Radiation Instruments and Measurements," pp. 367–466.

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Part I, "Introduction," pp. 1–10.
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Part III, "The IGY Earth Satellite Program," pp. 115–452.
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Part V, "Special Bibliography," pp. 474–475. (Annexes, pp. 475–508).

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Vol. X, Fifth Meeting of the CSAGI (Moscow) (in preparation).

Vol. XI, First Results of IGY Rocket and Satellite Research (in preparation).

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